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Patent

Attorney Docket No. 016660-190

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of

Hoi-Sing Kwok et al.

Patent No.: 6,919,947 B2

Issued: July 19, 2005

Title: COLOR VERTICALLY ALIGNED LIQUID CRYSTAL DISPLAYS

Certificate
SEP 0 6 2005
of Correction

REQUEST FOR CERTIFICATE OF CORRECTION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Issuance of a Certificate of Correction for the above-captioned patent is respectfully requested in accordance with the accompanying Form PTO-1050 (submitted in duplicate).

- ☐ The requisite Government fee of $100.00 (1811)
  - ☐ Is submitted herewith.
  - ☐ Is authorized to be charged to Deposit Account No. 02-4800.
  - ☐ Charge __________ to credit card. Form PTO-2038 is attached.
- ☒ It is believed that payment of a fee is unnecessary.

A copy of page 8 of the specification as filed in Serial No. 10/722,548 is attached.

The Director is hereby authorized to charge any appropriate fees under 37 C.F.R. § 1.20(a) that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. This paper is submitted in duplicate.

Respectfully submitted,

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Date: September 1, 2005

SEP 0 7 2005

PTO/SB/44 (08-00) (Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,919,947 B2
DATED : July 19, 2005
INVENTOR(S) : Hoi-Sing Kwok et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 4, lines 1-10, after "The general rules are:" should be changed to the following:

- $\alpha \sim 45^{o} + \frac{\phi}{2} + \frac{N\pi}{2}$
- $\gamma \sim \alpha$
- ϕ can be any value
- $d\Delta n \sim 1.9\mu m$

Here, N can be −1, 0 or 1.

MAILING ADDRESS OF SENDER:

PATENT NO. 6,919,947

BUCHANAN INGERSOLL PC
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SEP 07 2005

$$V = -D\int_0^d \frac{dz}{\varepsilon_{zz}(\theta(z))}$$

To obtain the conditions of the LCD that will provide the best color and contrast without the use of any color filters, an extensive calculation of the behavior of the LCD is performed. One important class of LCD is the vertically aligned VAN mode. This mode has the property that without any applied voltage, there is little or no retardation in the LC cell so that it can be very bright if the input and output polarizers are aligned properly. As well, the background color of the LCD can be chosen by arranging the polarizer angle properly.

In the optimization procedure, the deformation of the liquid crystal alignment is calculated as a function of applied voltage. Then the transmission spectra are calculated as a function of the applied voltage. The results are evaluated in terms of its colors. Finally, several modes where the color changes are vividly obtained as a function of applied voltage are recorded.

For the case of the single polarizer reflective display, the reflectivity is given by

$$R = \left|(\cos\alpha \quad \sin\alpha)\cdot R_\phi M_{LC}^{*} R_\phi^{-1} M_{LC}\cdot\begin{pmatrix}\cos\alpha\\ \sin\alpha\end{pmatrix}\right|^2$$

where the transformation matrix R is given by

$$R_\phi = \begin{pmatrix}\cos\phi & -\sin\phi\\ \sin\phi & \cos\phi\end{pmatrix}$$

The same procedure of varying (α, ϕ, $d\Delta n$) to find the best combination with the best colors can be performed as in the transmittive display. For the reflective display, the search is simpler because of the reduction of one variable. All the new combinations of (α, ϕ, $d\Delta n$) are recorded here as our inventions.

In preferred embodiments of this invention, several combinations of (α, γ, ϕ, $d\Delta n$) are provided for the case of transmittive displays and (α, ϕ, $d\Delta n$) for the case of reflective displays that will give colors to liquid crystal displays without any color filters. These colors can be tuned by applying the proper voltages to the LC cell.

The preferred embodiments are values of (α, γ, ϕ, $d\Delta n$) for obtaining vivid color LCD without using color filters. In these embodiments of the invention, the liquid crystal is of the negative anisotropy type and has a vertical alignment, so that the birefringence increases when a voltage is applied. However, the liquid crystal layer **3** is such that it has a certain degree of pretilt, which is obtained by treating the alignment layers, which are coated on the glasses **2** and **4**. The pretilt angle makes the alignment of the liquid crystal molecules to have an angle of 82°–88° instead of the perpendicular value of 90°. Additionally, the pretilt gives the liquid crystal molecules a direction in the horizontal plane. This pretilt direction determines the twist angle when a voltage is applied to the negatively anisotropic liquid crystals.

The general rules are:

$$\alpha \sim 45° + \frac{\phi}{2} + \frac{N\pi}{2}$$

$\gamma \sim \gamma$

ϕ can be any value

$d\Delta n \sim 1.9\ \mu m$

Here, N can be −1, 0 or 1.

In the first preferred embodiment of this invention, the twist angle is set to be 5°. The polarizer angles are at 45°. The transmission spectra are calculated for this display as a function of the applied voltage. FIG. **5** shows the transmission spectra of this first preferred embodiment. In this figure, the applied voltages are shown, together with the color of the display. The CIE color coordinates are also shown as well. It can be seen that many colors can be obtained. The background of the display is white or gray. Thus the color contrast of this display is great.

In the second preferred embodiment of this invention, the twist angle is set to be 90°. The polarizer angles are set to be 0°. FIG. **6** shows the transmission spectra of this second preferred embodiment. The transmission spectra are calculated for this display as a function of the applied voltage. In that figure, the applied voltages are shown, together with the color of the display. The CIE color coordinates are also shown as well. It can be seen that many colors can be obtained. The background of the display is white or gray. Thus the color contrast of this display is great.

In the third preferred embodiment of the present invention, the display is of a reflective type with only one polarizer. The configuration is as shown in FIG. **4**. The values of the various parameters are the same as in the first preferred embodiment, except that the cell gap-birefringence product is halved, at 0.95 μm. The output spectra as a function of applied voltages are similar to the case of the first embodiment, except that the voltages needed are lower due to the thinner cell gap.

In the fourth preferred embodiment of the present invention, the display is of a reflective type with only one polarizer. The configuration is as shown in FIG. **4**. The values of the various parameters are the same as in the second preferred embodiment, except that the cell gap-birefringence product is halved, at 0.95 μm. The output spectra as a function of applied voltages are similar to the case of the first embodiment, except that the voltages needed are lower due to the thinner cell gap.

What is claimed is:

1. A liquid crystal display comprising an input polarizer, an output polarizer, and a liquid crystal cell in between said input and output polarizers characterized by a twist angle, a cell thickness and a birefringence of the liquid crystal, such that:

(a) the liquid crystal has a negative dielectric anisotropy,

(b) the alignment of the liquid crystal in the zero volt state is substantially vertical and perpendicular to the liquid crystal cell,

(c) the liquid crystal cell is treated such that there is a pretilt angle of the liquid crystal molecules near the cell surfaces away from the vertical direction, and thus has a vectorial component on the plane of the liquid crystal cell (the x-y plane),

(d) the said pretilt angles of the liquid crystal molecules gives rise to a preferred twist angle of value ϕ, where ϕ can be any value, as viewed on the x-y plane,

(e) the input polarizer angle α has a value of $\xi - \phi/2 + N\pi/2$ relative to the tilt direction of the input director of the